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## SHORT REPORT

## Pre-operative Radial Arterial Diameter Predicts Early Failure of Arteriovenous Fistula (AVF) for Haemodialysis

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**Introduction.** Long term patency of arteriovenous fistula (AVF) is relevant to the management of end stage renal failure (ESRF) patients on haemodialysis (HD). We evaluated the role of routine radial arterial duplex for imaging radial artery before AVF formation to investigate the relationship between radial artery internal diameter (ID) and AVF patency.

**Methods.** 21 patients with ESRF were examined by duplex sonography before AVF formation, 1 day, 1 week, 4 week and 12 weeks post AVF formation. For assessment of AVF patency, patients were divided into 2 groups. Group-1, 11 patients with radial artery ID <1.5 mm and Group-2, 10 patients with radial artery ID >1.5 mm. Measurement of radial artery blood inflow rate was calculated from mean blood flow velocity and vessel diameter. All AVFs were constructed on the forearm using autologous veins.

**Results.** In Group-1, 5 patients (45%) showed immediate thrombosis of AVF graft. All patients in group-2 had patent AVF at 12 weeks. Pre-AVF formation radial artery blood inflow rate between two groups was not significantly different ( $p = 0.06$ ). Radial artery blood inflow rate was consistently and significantly higher in group-2 at all later time points with  $p$  value of <0.01 (Mann Whitney test).

**Conclusion.** There was a high failure rate of AVF with radial artery ID of <1.5 mm. In the presence of small radial arteries primary access AVF in the upper arm should be considered.

**Keywords:** Arterio venous fistula; Radial artery duplex; Hemodialysis; Arterial inflow.

### Introduction

Most patients with end-stage renal failure still spend an appreciable amount of time on haemodialysis (HD), either as a definitive treatment or waiting for transplants. Satisfactory blood flow through an arteriovenous fistula (AVF) is essential for adequate haemodialysis in patients with end stage renal disease. It has been recommended that the radiocephalic AVF should be the first choice for vascular access for HD,<sup>1–3</sup> although these fistulae continue to have a high incidence of early failure.<sup>4–6</sup>

The most frequent complications with AVFs are lack of immediate patency after construction, failure to mature and inadequate flow during haemodialysis treatment. Dialysis access procedures and complications represent a major cause of morbidity, hospitalization, and cost for chronic dialysis patients. To improve the outcomes of haemodialysis access procedures, the Dialysis Outcomes Quality Initiative (DOQI) guidelines have encouraged attempts to place an autologous arteriovenous (A-V) fistula, rather than an A-V graft, due to their superior long-term patency and lower rate of complications. They also recommend a distal first approach, so that the possibilities for more proximal fistulas in the ipsilateral arm are preserved if the first fistula fails.<sup>7</sup>

Colour-coded Doppler ultrasound scans are non-invasive, inexpensive, and an excellent modality for haemodialysis access evaluation. Doppler ultrasound

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has been shown to yield significant anatomical data that correlates with angiographic studies.<sup>8</sup> Further attempts have been made to use this non-invasive method to predict patients likely to have immediate fistula dysfunction and to identify those at high risk of future access failure.<sup>9,10</sup>

The objectives of our pilot study were to evaluate the role of duplex sonography for assessment of arteries before AVF formation for haemodialysis, to study the relationship between radial artery internal diameter (ID) and early failure rate of AVF and to study relationship between radial artery ID and radial arterial blood inflow rate.

### Methods

Patients ( $n = 21$ ) were recruited prospectively and investigated as a part of routine vascular laboratory surveillance clinic for AVF. The patients were classified into two groups. Group-1: Patients with radial artery internal diameter (ID)  $< 1.5$  mm and Group-2: Patients with radial artery internal diameter (ID)  $> 1.5$  mm. The cut off point of 1.5 mm was used because it was observed in authors vascular laboratory that, majority of the failed AVFs at our institution had pre-operative radial artery internal diameter of  $< 1.5$  mm. This also is consistent with previous published data where patients with radial artery internal diameters of 1.5 to 2.0 mm had a high AVF failure rate.<sup>11</sup> Five measurements were obtained for each group, before AVF formation and 1-day, 1 week, 4 weeks, and 12 weeks after AVF formation.

The radial artery was palpated at the wrist before examination with duplex sonography in order to mark the direction and exact position of the vessel. Duplex scanning was performed using Acuson (Computed Sonography System, California, USA). A 2-D linear probe 5.0 and 7.0 MHz was used. The M-mode was used for accurate measurements of the systolic radial arterial internal diameter. The systolic cross sectional area of the radial artery was measured using B-mode image, which is displayed simultaneously and frozen on the screen. The calculation for cross sectional area was performed by the automatic function on the Acuson equipment. Time Averaged Velocity (TAV) was calculated directly from a Doppler spectral waveform. The volume flow was obtained from TAV and the cross-sectional surface area. All the ultrasonic imaging was performed by the same operator to ensure consistency of the measurement procedure.

The data were analysed using SPSS for Windows. Two-tailed hypothesis were used and tested at either 5% significance level or 1% level of significance.

The Mann-Whitney U test was used to compare variables such as artery diameters and blood flow rates. The mean and the median were used to summarise data.

### Results

The 21 patients with ESRF (15 men, 6 women) had mean age of 52 years. The patients were classified into two groups as follows.

Group-1: Patients with radial artery internal diameter  $< 1.5$  mm (11 patients)

Group-2: Patients with radial artery internal diameter  $> 1.5$  mm (10 patients)

In Group-1, 5/11 (45.5%) of the radial artery AVFs had failed within 12 weeks of construction. In contrast, in Group-2 patients all of the AVFs were patent at 12 weeks.

Group-1 and the Group-2 are compared in Table 1. Before AVF, the radial artery blood inflow rate in Group-2 (21.4 ml/min) was higher than in Group-1 (18.20 ml/min),  $p = 0.06$ . After AVF Group-2 had a statistically significant increase in radial artery blood inflow rate, compared to Group-1, at all the time points. Blood flow rates increased with time for both groups but the mean of blood flow rates for the Group-2 were higher than for Group-1 at all time points.

### Conclusion

This study indicates that pre-operative radial artery diameter is a useful guide to the future patency of radial artery AVFs. Radial arteries with a diameter of  $< 1.5$  mm had an almost 50% risk of immediate fistula dysfunction as compared with larger radial

**Table 1. Radial artery blood inflow rate comparison between two groups**

Time point	Group	Median blood flow rate (ml/min)	P-value #
Pre AVF	Group-1	18.20	0.06
	Group-2	21.40	
1 day post AVF	Group-1	133.60	0.00**
	Group-2	152.90	
1 weeks post AVF	Group-1	163.60	0.01**
	Group-2	180.60	
4 weeks post AVF	Group-1	279.80	0.04*
	Group-2	297.10	
12 weeks post AVF	Group-1	347.90	0.03*
	Group-2	521.10	

(# Mann-Whitney test, \*\* Significant at 1% level, \* Significant at 5% level).

arteries. Our data supports similar previous studies. Some authors suggest that primary access should not be performed if the diameter of the artery is <1.6 mm.<sup>5</sup> However, most surgeons probably would still try to create an AVF irrespective of arterial diameter.

After AVF construction between the radial artery and accompanying cephalic vein, the peripheral resistance for the radial artery feeding the fistula is decreased thereby increasing the rate of blood flow. The second part of this study investigated the relationship between the internal diameter of the radial artery feeding the fistula and the rate of radial artery blood inflow. A relatively similar study was designed by Wong *et al.*, 1996<sup>5</sup> where intra and post operative blood inflow was measured in radiocephalic fistulae. They concluded, intraoperative fistula blood flow did not correlate with the outcome of the operation, probably due to vessel spasm from manipulation. However, blood flow velocities measured non-invasively 1 day after the operation were significantly lower in fistulae that failed early compared with those that were adequate for haemodialysis. Most of the increase in blood inflow occurred within the first 2 weeks of surgery.<sup>5</sup> Our data confirm these observations, showing persistently increased radial arterial blood inflow rate after AVF formation in group-2 with radial arterial diameter >1.5 mm. Persistent high blood inflow through the AVF is required for its long term patency.

In summary, we have demonstrated associations between radial artery diameter and early AVF patency as well as radial artery blood inflow rate. In the presence of a small diameter radial artery a primary upper arm AVF might be indicated.

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